

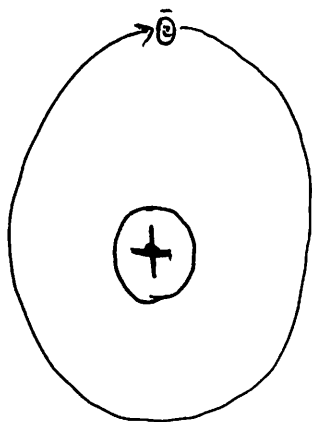
Ch 4

Why Rutherford was wrong

Rutherford discovered the nucleus. (Gold foil Exp)

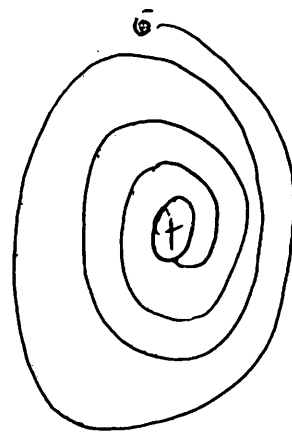
Said it was small and dense
and +

He hypothesized that the e^- orbited
the nucleus in much the same way
planets orbit the sun.



Rutherford's Model

Think about it
(Attraction of
opposite charges)
 e^- spiral into
Nucleus



Rutherford wrong
lead to Atoms collapse

also no explanation of reactions

Ch 4 Hmwk A

pg 108 Q5, 4
pg 121 Q5

AF

pg 122 Q16 *old*
pg 123 Q36, 41 (acc)
pg 124 App Q 11
pg 125 App Prob 2, 3, 6

H

pg 123 Rev. Conc 29, 34
pg 124 Prob 2, 8, 9

New Read Ch

pg 97 1, 5

pg 116 4, 5

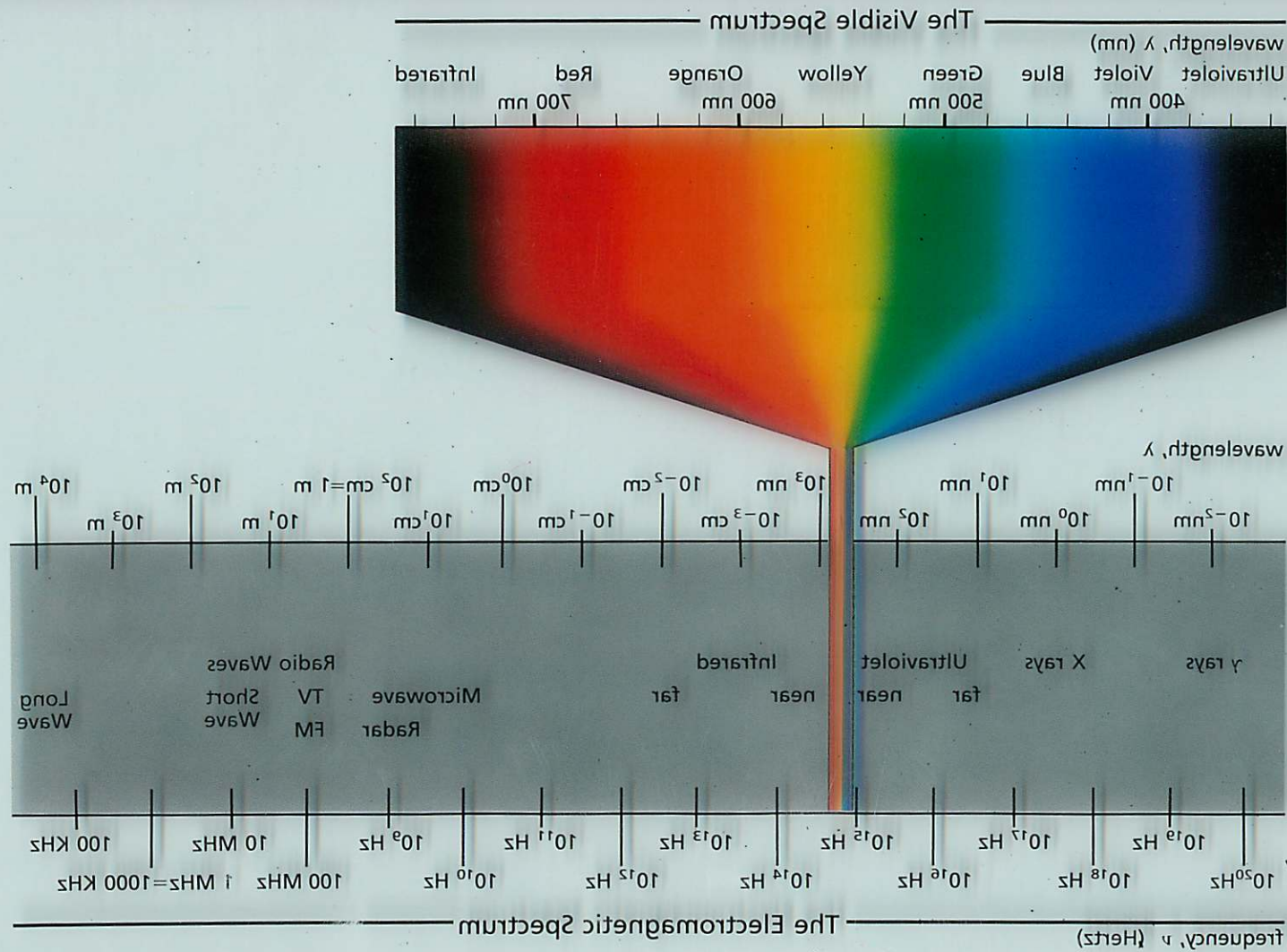
pg 118 8, 10 (Rev Conc)

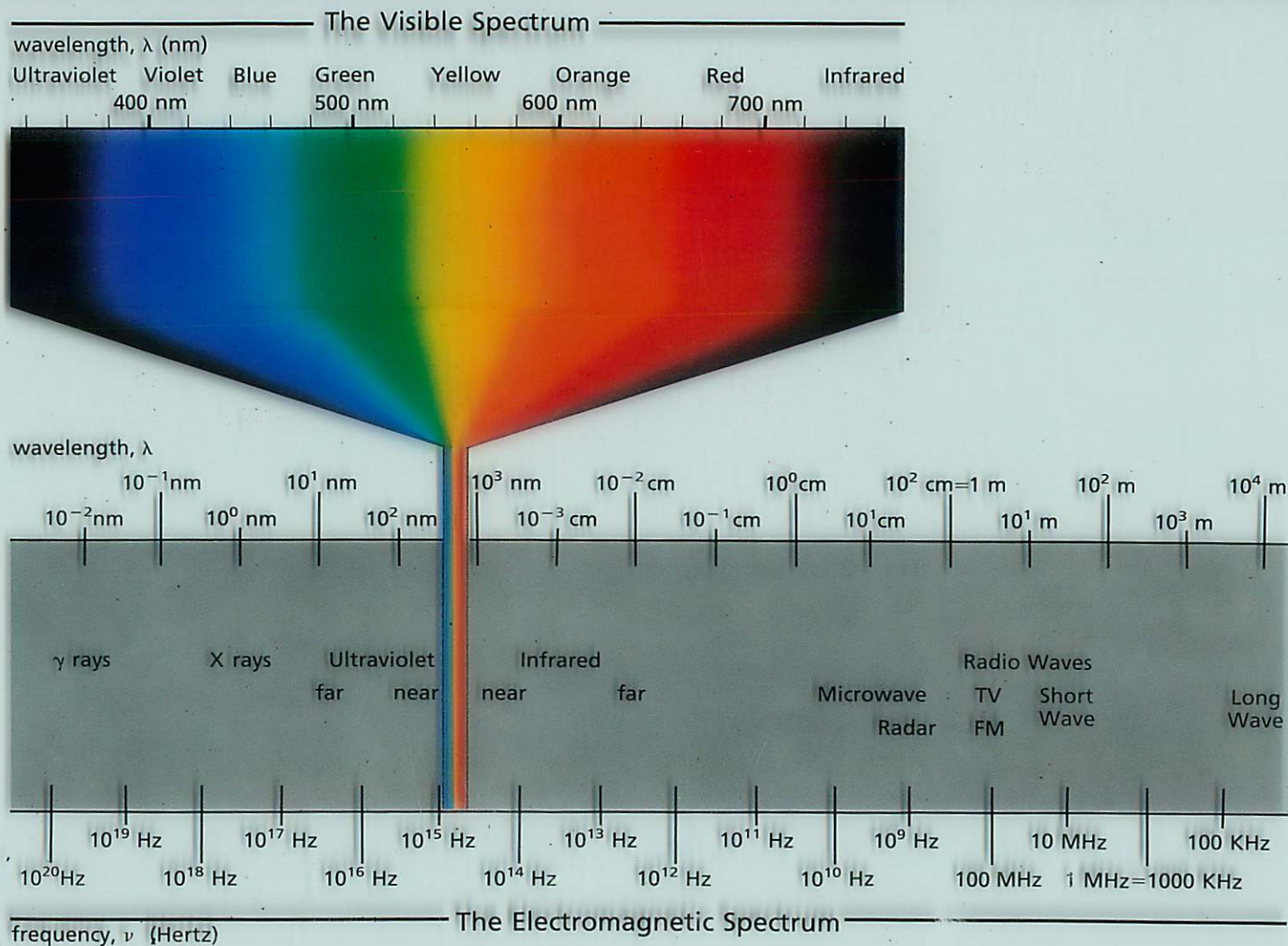
pg 119 23, 24, 30, 32

p 120 43

Electromagnetic Spectrum

Modern Chemistry
Figure 4-3





BACKGROUND NEEDED TO UNDERSTAND NEW THEORY

RADIATION moves as WAVES (like water waves)
Properties of waves:



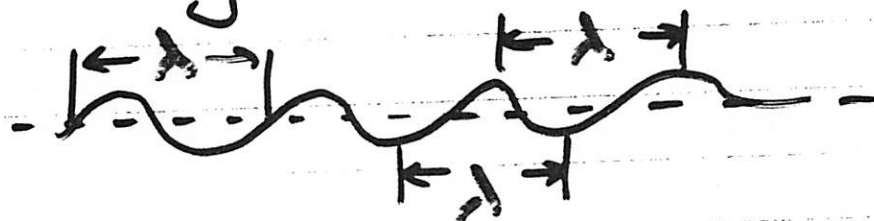
1. Speed (c) label: $\frac{\text{cm}}{\text{sec}}$

spring

sound

light

2. wavelength (λ) label: cm (any length label)



wavelength is not a shape, it's a distance

3. frequency (ν) label: $\frac{\text{waves}}{\text{sec}}$ or hertz or $\frac{1}{\text{sec}}$

Relationship of c, λ, ν

3

$$C = \nu \lambda$$

The speed of a wave = frequency times wavelength

(ex) What is the speed of a wave in cm/s, if it has a wavelength of 10. cm and a frequency of $5 \frac{1}{\text{sec}}$.

$$C = 10 \text{ cm} \times 5 \frac{1}{\text{Sec}} = 50 \frac{\text{cm}}{\text{Sec}}$$
$$\frac{10 \text{ cm} \times 5}{\text{Sec}} = 50 \frac{\text{cm}}{\text{Sec}}$$

5 waves/sec

(ex) What is the frequency of a wave in $\frac{1}{\text{min}}$ if its speed is 30 cm/s and its wavelength is 2.0 m

$$\nu = \frac{C}{\lambda} = \frac{30 \text{ cm}}{\cancel{\text{s}}} \times \frac{60 \cancel{\text{s}}}{\text{min}} \times \frac{1 \text{ m}}{100 \cancel{\text{cm}}} = 9 \frac{1}{\text{min}}$$

nine waves per minute

For all electromagnetic radiation

$$C = 3.00 \times 10^{10} \text{ cm/s} \text{ or } 3.00 \times 10^8 \text{ m/s}$$

Bright Line Spectra

Continuous



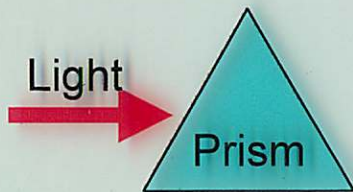
Hydrogen



Carbon



Helium



4

Waves can transmit energy

↳ Light, sound, etc

We cannot see sound or most light waves

But they exist, transporting energy

Light waves are part of the EM spectrum

↳ consisting of all electromagnetic radiation arranged by freq or wavelength

EM radiation is just energy. Many things emit it. Machines, Stars.

$C = \lambda \nu$ is the same for EM

speed of C though is always

$$3.00 \times 10^8 \text{ m/s}$$

EM Spectrum

Types

Low E

High

Radio | Micro | IR | ^{vis} | UV | X-Ray | Cosmic Rays

ROYGBIV

2 Behavior's of light not explained 5 By wave theory

1. When Heat metal it glows
 - Gives off radiation in the (given off) visible spectrum

2. Photoelectric Effect when light shiner on certain metals e^- are emitted (absorbed)

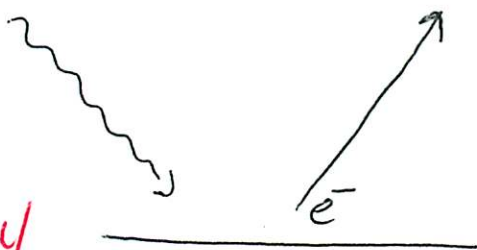
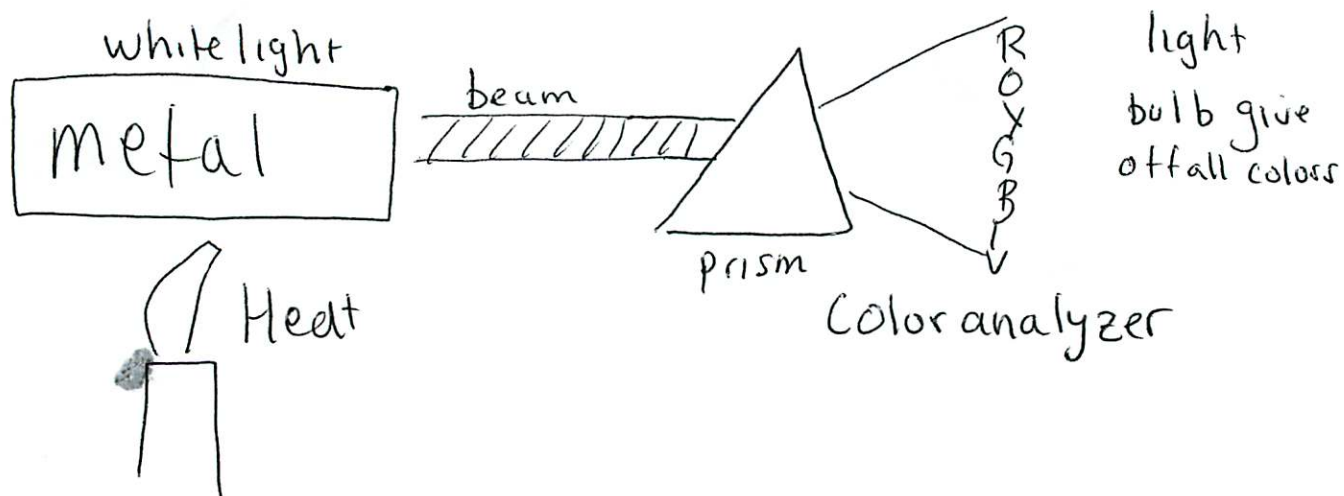


Fig 4-4

(There is a minimum E needed after
light must be a certain λ to eject e^-
didn't know why?)

These phenomena are explained
if we examine light as a particle

Max Planck → experiment w/ heating metals



light Bulbs give off ^{light} ~~all~~ ⁱⁿ all ~~wavelengths~~ ^{colors}

→ a continuous spectrum

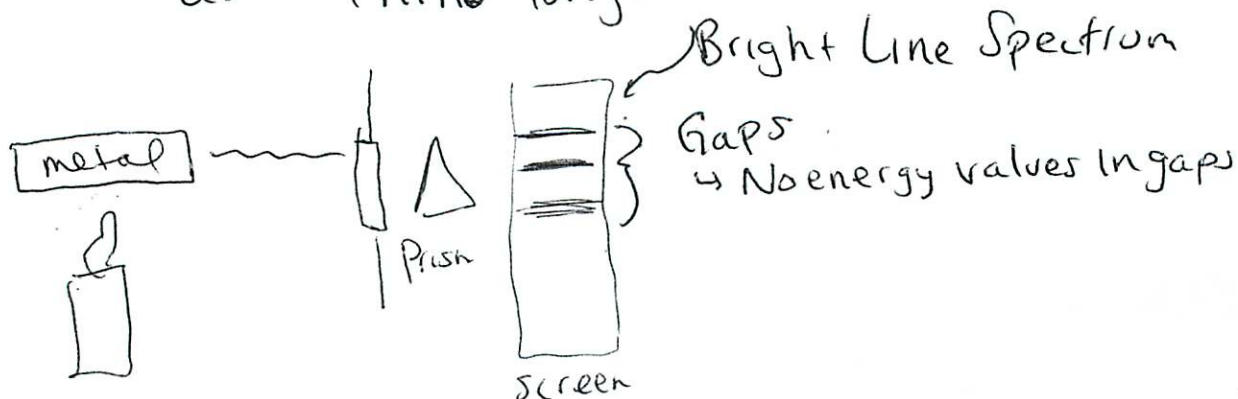
Where all colors are blending together. (separated by prism)

all Spec. Sops

Plank

Some elements only give off certain specific colours

↳ Spectroscope sorts colors and presents them as thin Bright line



Planck saw these Bright lines and thought about them

Using Bright line Spectrum as evidence
He deduced:

Hot Matter did not lose energy continuously

1. \hookrightarrow lost energy in specific amounts called

Quanta

Notes \rightarrow on back

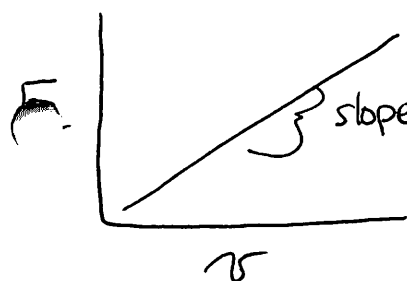
2 Energy like matter, both are particles
(mainly b/c they come in packets)
atoms are packets of matter

3. Einstein called packets of light "photons"

4 Each line in Bright line spectrum

~~Is a~~ Is a Quantum of energy

5. When E of emission was graphed it was found to be \propto proportional to ν
got straight line



slope $6.62 \times 10^{-34} \text{ J} \cdot \text{sec}$

energy
(J)

$$y = mx$$
$$E = h\nu$$

Planck's
constant
($6.62 \times 10^{-34} \text{ J} \cdot \text{sec}$)

energy of
1 quantum
freq ($1/\lambda$)

$E \propto \nu$
directly prop

7a

Why light said to be quantized

B/c each γ has own E and no other
why quantized

(Use a standing wave to
Demo quantization)

Only goes up by $\frac{1}{2}$ numbers

8
 $E = h\nu$ also was used to explain photoelectric effect.

why \rightarrow absorption of light will not induce e^- emission if ν (therefore E) is too low.

But if ν is right even a few photons will dislodge e^- .

$E = h\nu$ for EM only but $c = \lambda\nu$ for all waves

$$c = \lambda\nu \rightarrow \nu = \frac{c}{\lambda} \rightarrow E = \frac{hc}{\lambda}$$

Do problems. \rightarrow Energy of quanta w/ ν 10.0 $\frac{\text{waves}}{\text{sec}}$

Energy of photon w/ λ of 10cm

Give wksh.

Bright line revisited

9

Ne, H; other elements all produce Bright line Spectra
(Fig 4-11)

1913

why? Neils Bohr interprets Planck's work

H Spectra				
	4150 Å	4250 Å	4800 Å	6480 Å
	$7.31 \times 10^{14} \text{ Hz}$	6.91×10^{14}	6.17×10^{14}	4.57×10^{14}
	410 nm	434	486	656

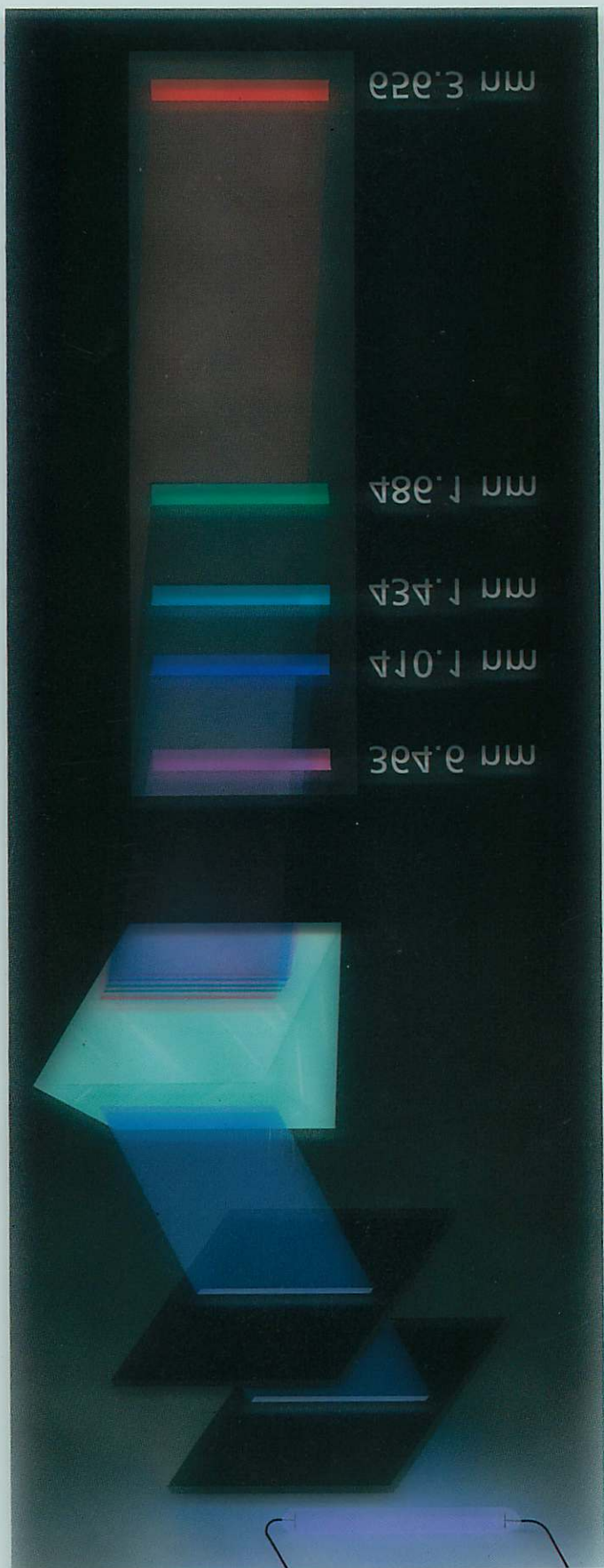
find $\lambda + E$ of each

Why did they exhibit this Bright line Spectrum

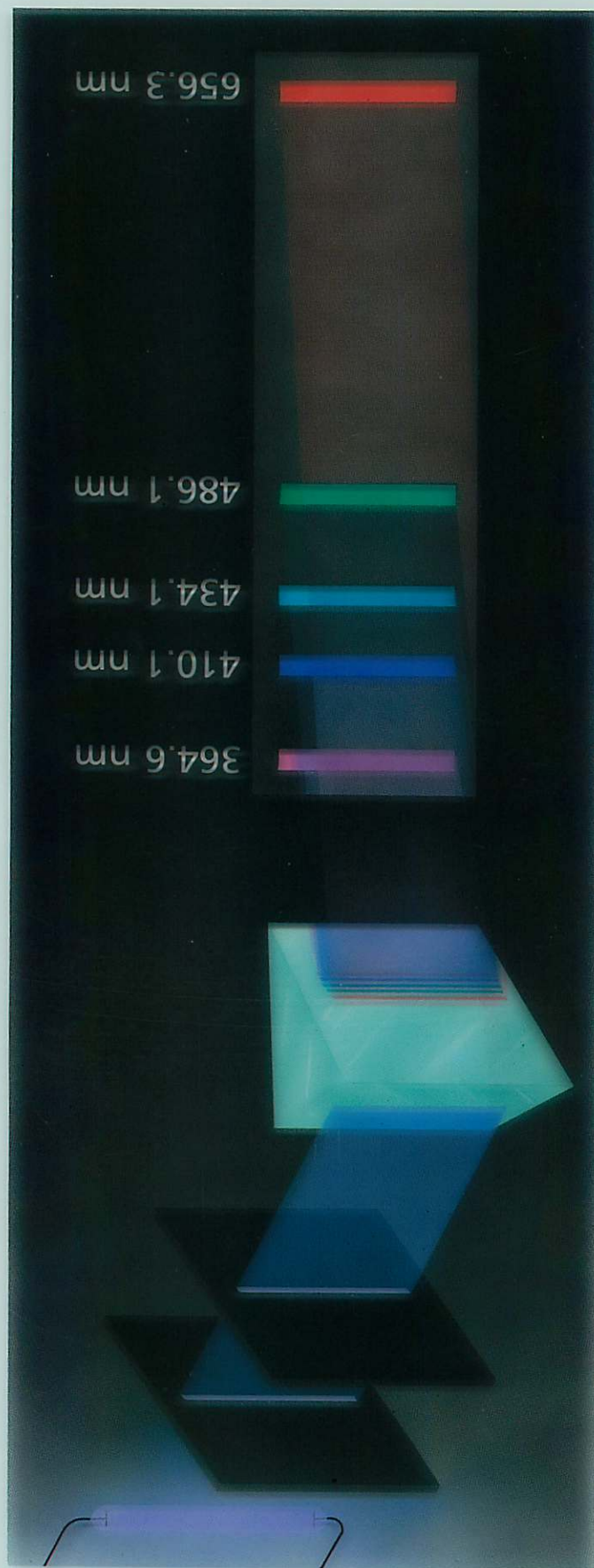
Bohr \rightarrow said atoms of H were absorbing E then releasing it in certain σ of light.

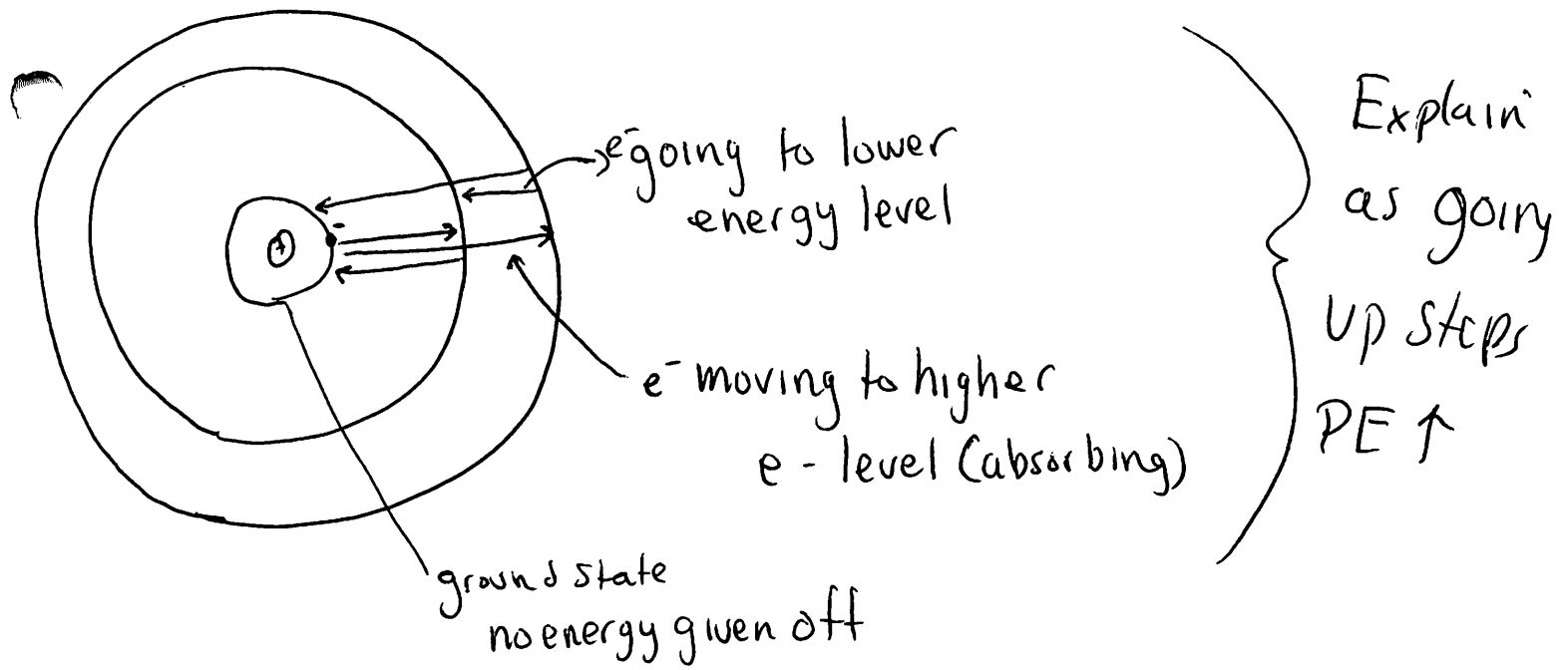
Suggest the H atoms were quantized

H atom \rightarrow only $1e^-$ (~~energy~~)
~~As long as e^- stay in level~~ e^- exist only
in certain energy levels when they absorb
Energy they are raised to a higher level for
only a short time. Then go back to lower
level. (B/come excited)



How did the bright-line spectra of hydrogen and helium differ?





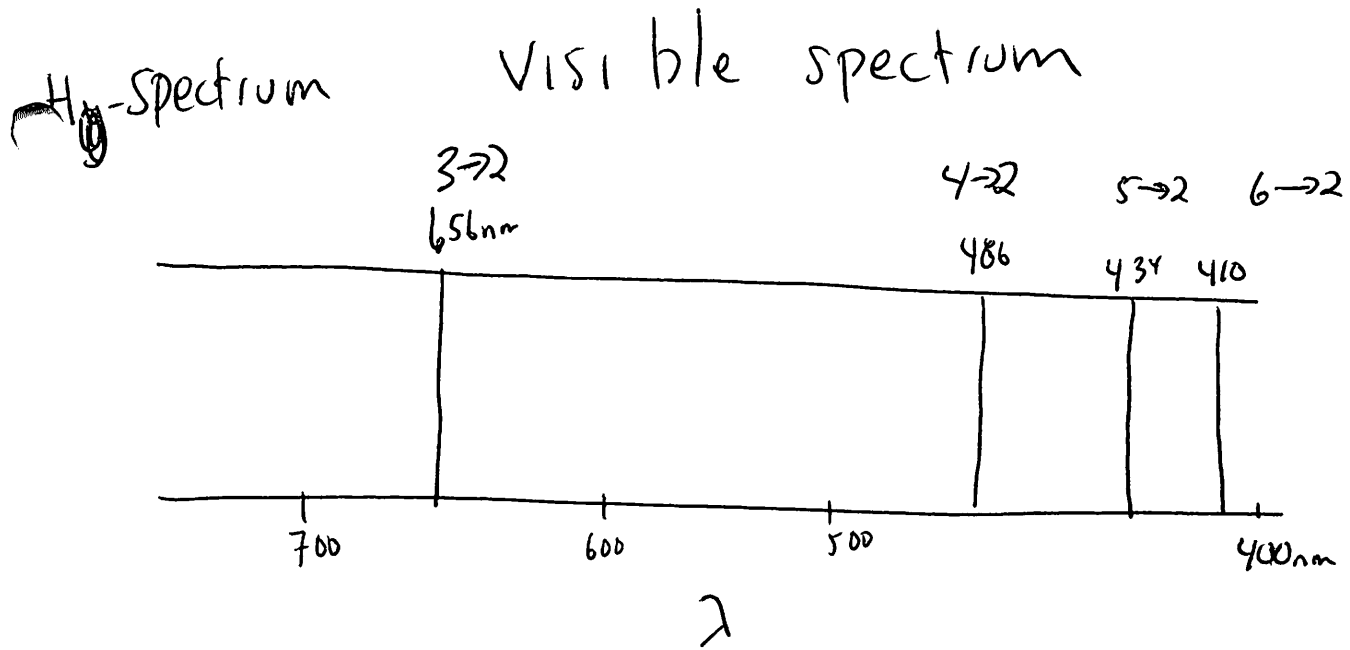
Bohr said

1. As long as e⁻ stays in one level, no energy given off. &

2. When atom excited (heat or elec) e⁻ jumps to a higher level - excited state
Excited state is unstable

3 e⁻ goes back to lower level giving off ~~light~~
a quantum of energy for each level

It drops → these are the bright lines we see



Each line result of e^- going from

different energy levels

Other Bright lines were seen in other λ that are not visible

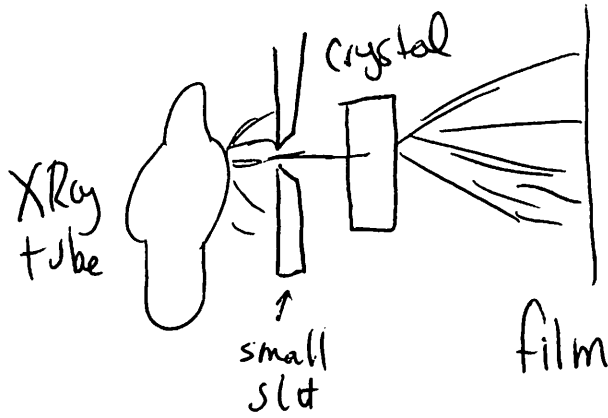
Downside - Bohr's model only good for H ~~is~~ all failed when applied to other atoms.

Also it did not explain Reactivity

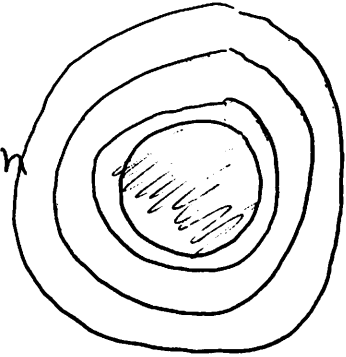
Diffraction Patterns (scattering patterns)

13

Ray

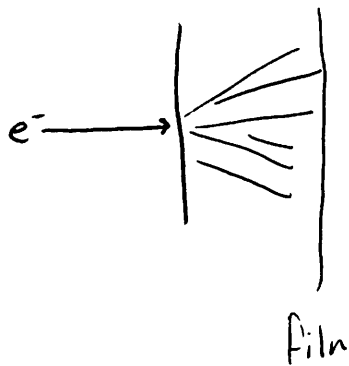


Give Pattern
same pattern

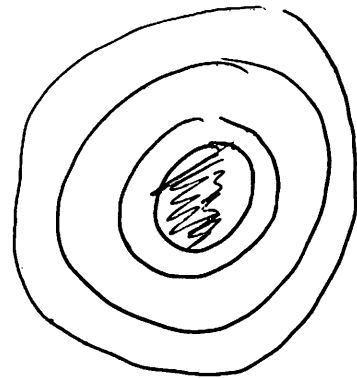


Diffraction of e^-

pass e^- through through thin foil



Give
same pattern



Can say that e^- have same pattern as
X Rays. X Rays are waves then e^- have
wave properties

Quantum Model

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1924 de Broglie \rightarrow e^- might have wave particle nature

\hookrightarrow reasoned that Bohr's H model consistent w/ wave behavior

E_x waves confined in a space have only certain ~~energies~~ freq thus certain E

$$E = h\nu$$

If we thought of ~~waves~~ e^- as waves confined to the space around nucleus this explains why certain energies (and freq) are only possible by energies

Further research shows e^- and Xrays have similar diffraction patterns



Schrödinger - liked deBroglie's idea about waves; e^- 14

Did some advanced calculations

↳ deduced and correctly described behavior of waves in the EM spectrum.

Describes Behavior of e^- in terms of quantized energy changes

↳ Quantum mechanics

Schrodinger

vs.

Bohr

e^- are in orbits

e^- are in orbitals



3-D region about nucleus where e^- may be located

↳ e^- clouds shows probable location of e^-

↳ can't pinpoint ~~by~~ waves are not physical bodies that are precisely located

explain Reactivity

↳ Thought e^- in specific pt in an orbit

attempt to explain e^- as particles

No explain Reactivity

Compare from energy standpoint orbitals treated like orbits

probable location for He^- is at the point of Bohr lowest energy orbit

~~Energy needed to go from~~

E needed to go from low to high orbital when drop ↓ give off same E

Present Atomic theory (xture) Based on work by 19

Schrödinger → wave eqn. - correctly described behavior of EM waves

Einstein → Energy is Matter ($E=mc^2$)

de Broglie - matter is Energy (X-Ray diffraction)

Heisenberg - If e^- wave, can't simultaneously know where e^- and how fast it is going

All make up the Quantum Model

1. e^- is a wave (E), not a particle (matter)
    ~~~~~                      o o o

2. wave-particle duality - Whenever decreasing amounts of matter and E are measured - indistinguishable

experiments show

$e^-$  behave like E (de Broglie), or Matter (CET)

light behave like energy (wave) or Matter (photoelectric)

3. We will never be able to find an  $e^-$  in an atom, and measure where it is and how fast it is going

Probability - likelihood of occurrence

Ex Low probability finding a <sup>particular</sup> WZHS student in during class (b/c majority in class)

The orbital describes the probability that an  $e^-$  will be found in a certain area but ~~not~~ does not indicate position of  $e^-$ .

Quantum ~~the Atomic Orbital~~ Model

Only tells us where we are likely to find an  $e^-$  Not where it is or where it is going.

Bohr's Model

Thought  $e^-$  orbit nucleus

C  
O  
n  
t  
a  
i  
n  
s

Quantum Model

3-D region of different energy levels  
Can't pin point b/c  $e^-$  are not physical bodies

Compare

E needed to go from 1 level to the  
Next



# 4 things QM theory tells us

- ① Energy level of each  $e^-$  (avg distance from nuc)  
Called principle Quant # ( $n$ )

1, 2, 3, 4, 5  $\longrightarrow \infty$

dist inc  
 $\xrightarrow{E \text{ increase}}$

referred to as  
shells

- ② Orbital Quantum #  $\rightarrow$  shape of orbital (l)

$\hookrightarrow$  sublevel of each  $e^-$

s, p, d, f, g


$\xrightarrow{\text{increasing energy}}$

## 3. Space orbital


s = 1 - - -

 sphere

p = 3 - - -

 propeller

d = 5 - - -

 4 leaf clover

f = 7 - - -

none

g - - ?

## 4 spin of $e^-$

direction of spin for -  $1/2$   
(atoms viewed to magnetic  
earth has mag field (spin)  
 $e^-$  too must spin)

4 Quantum #'s

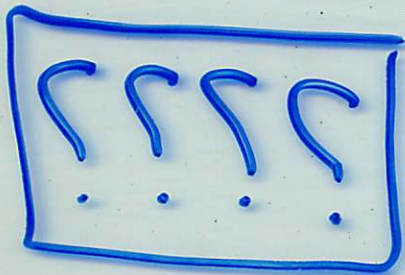
Schrödinger's wave eqn

$$E\psi = -\frac{h^2}{8\pi^2m} \left( \frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2} \right) + V\psi$$

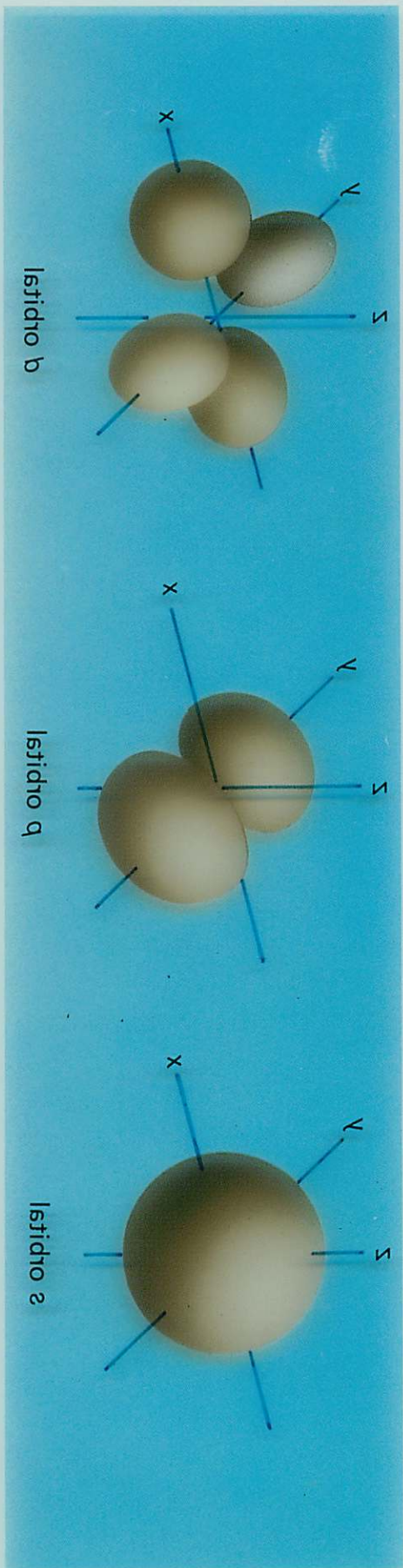
????  
.

Zurück in die Natur

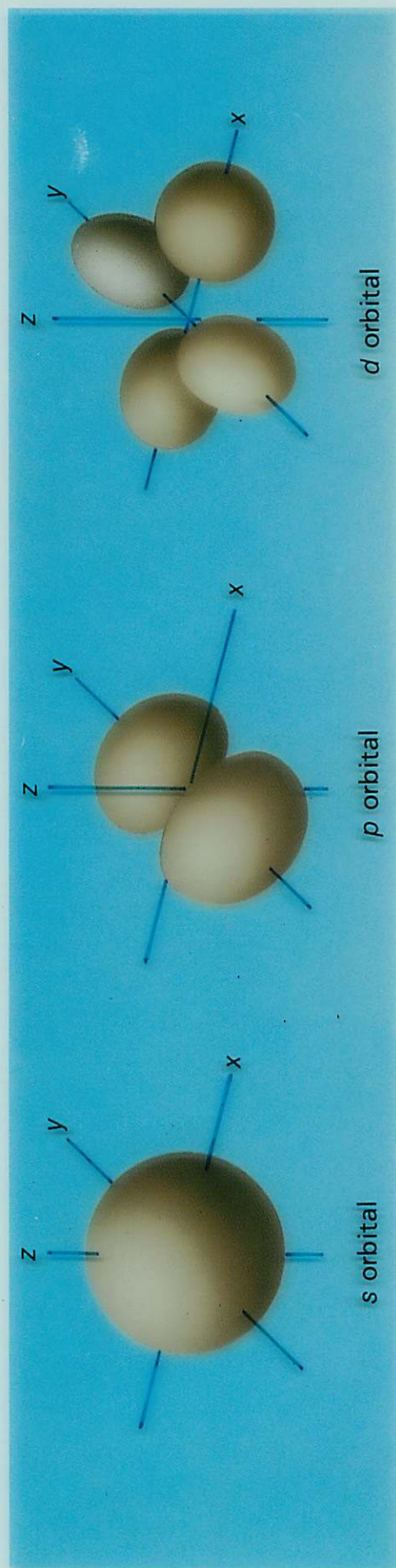
$$E_{\text{eff}} = \frac{8\pi\epsilon_0}{N_s} \left( \frac{g_{x_s}}{g_{y_s}} + \frac{g_{y_s}}{g_{z_s}} + \frac{g_{z_s}}{g_{x_s}} \right) + N_s$$





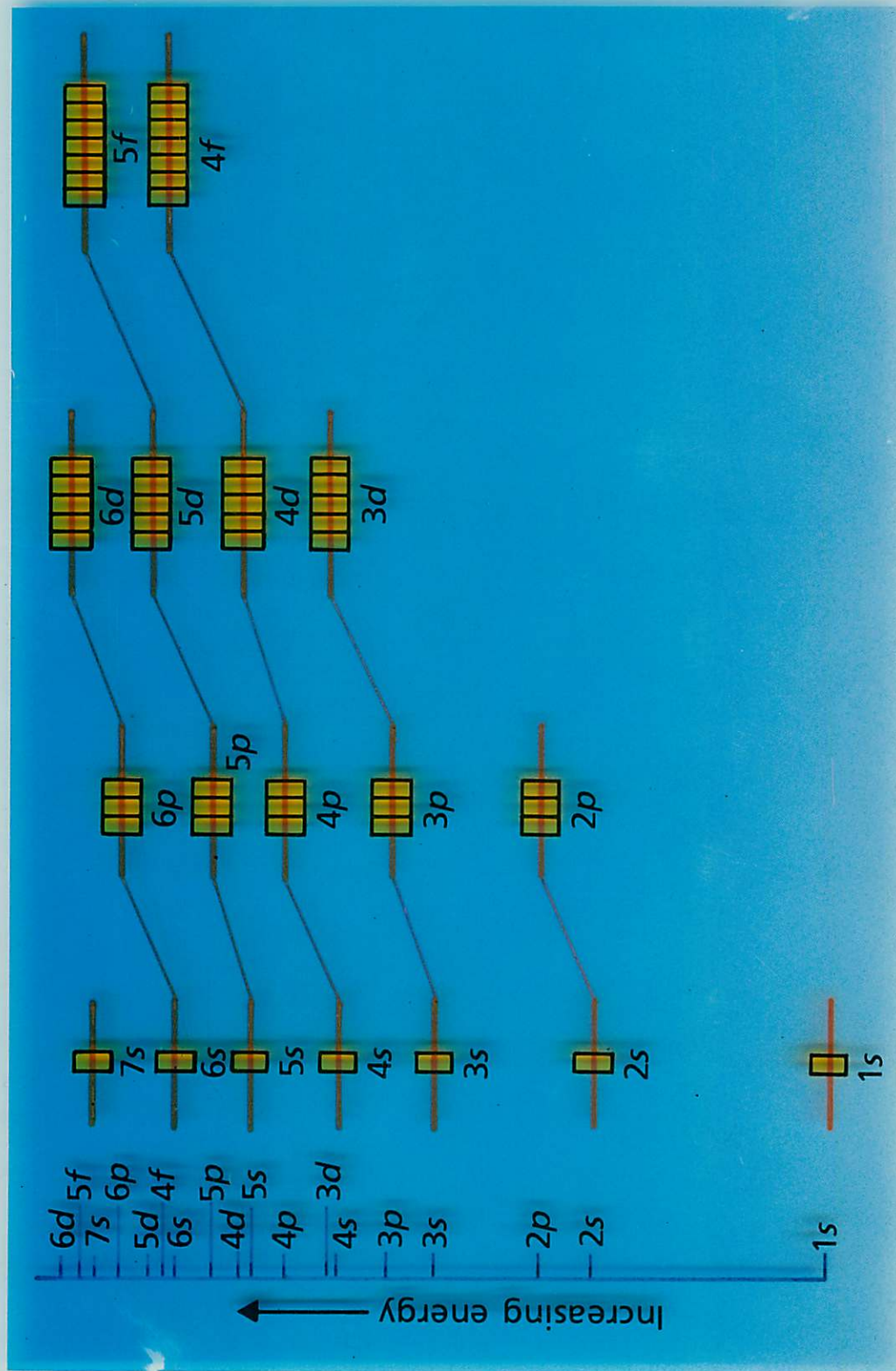


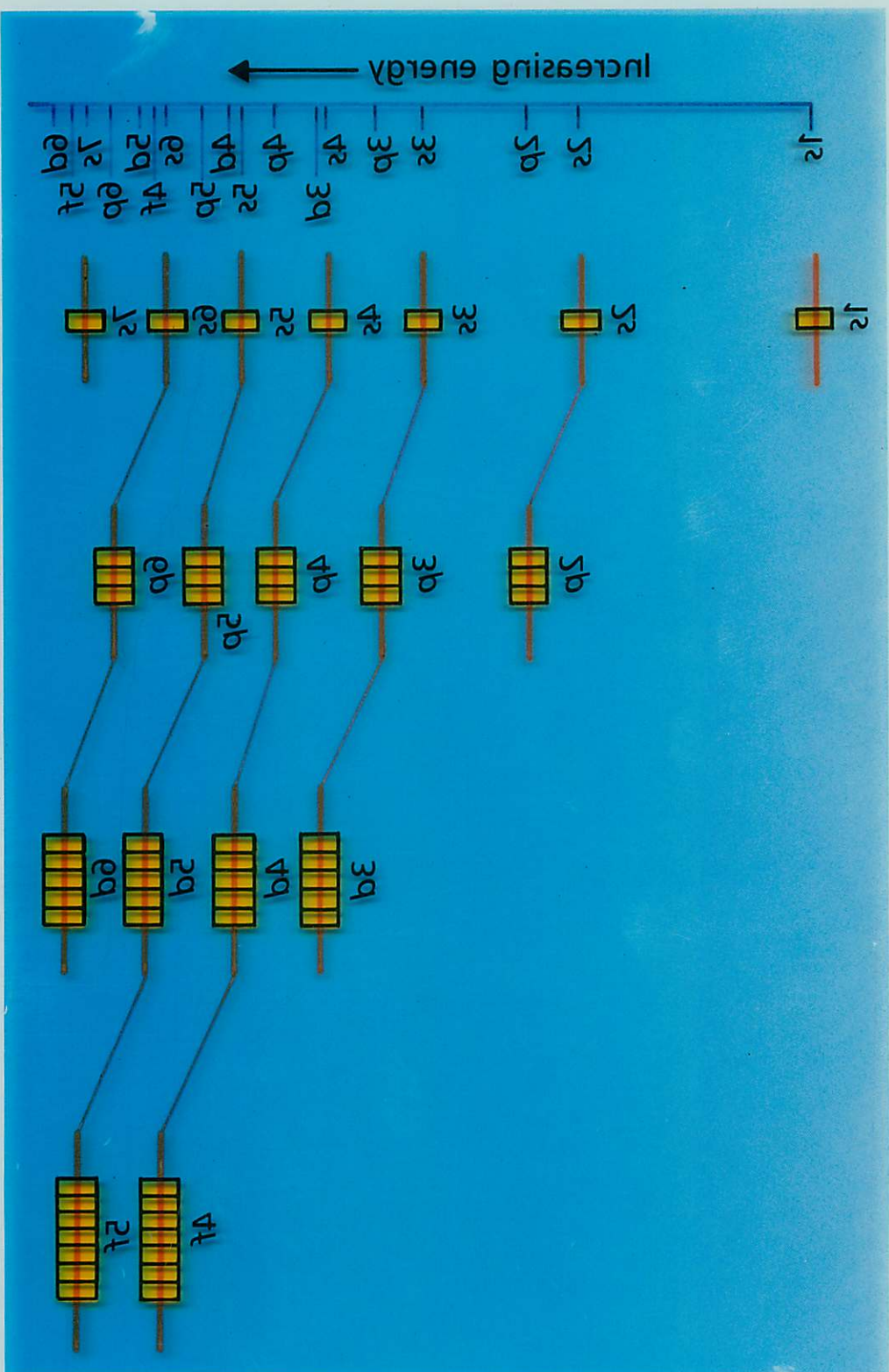
## s, p, and d Orbital Shapes





## Orbital Energy Diagram

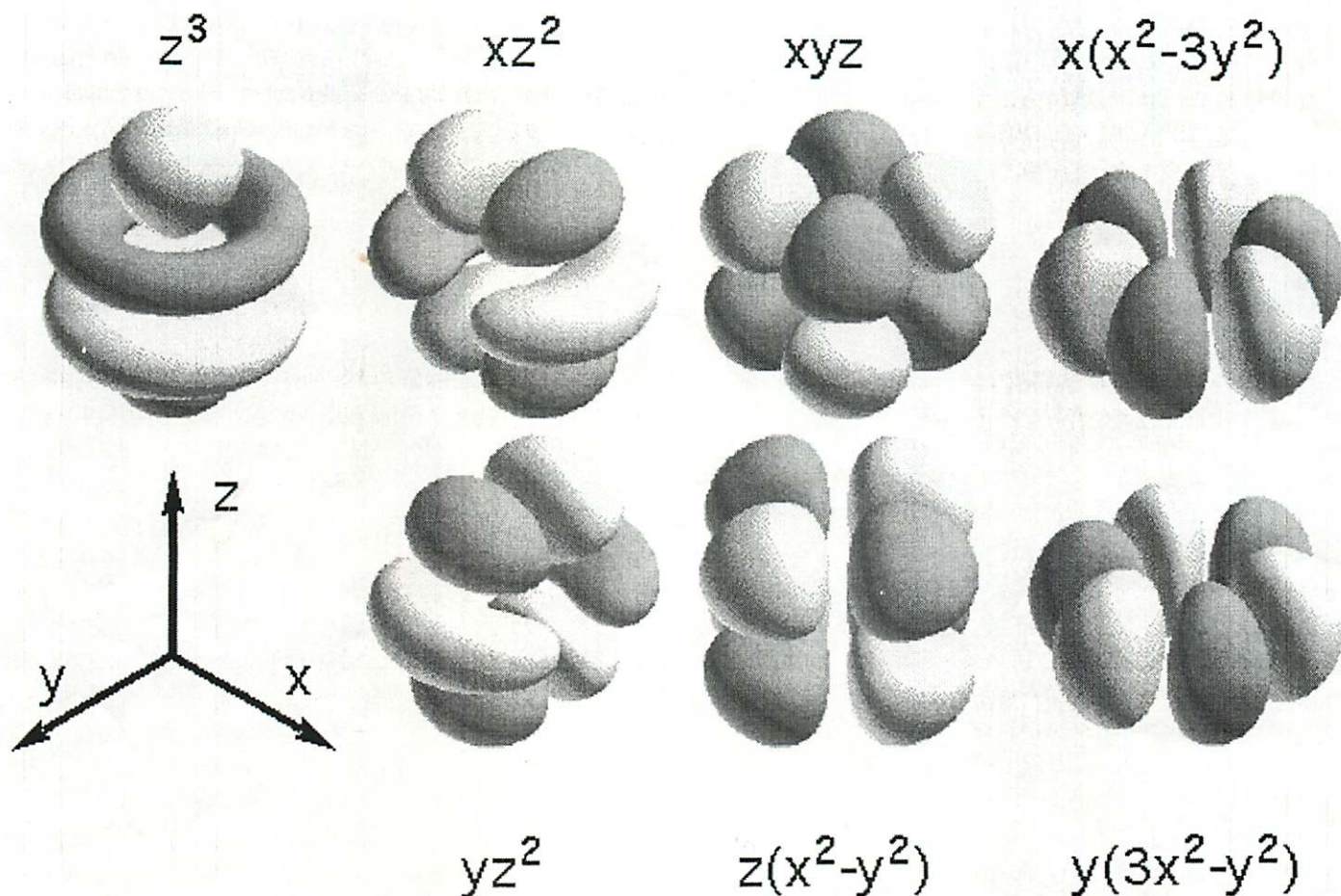




Orbital Energy Diagram

Figure 4-17





*f-orbitals*

D. L. Cooper  
University of Liverpool

# Let's Get Down to Business

18

## Election config notation

n sublevel  $\oplus e^-$   
 ↑  
 energy level

Example  $\overset{\text{Li}}{\cancel{\text{He}}} 1s^2 2s^1$   
 $\text{H } 1s^1$      $\text{He } 1s^2$

superscript for # of  $e^-$  in that level

## Orbital Notation

Gives spin of  $e^-$

↓ Give Symbol  
 $\text{H } \uparrow$  line  
 $1s \leftarrow$  principle + subshell #  
 $e^-$  indicated by ↑  
~~to extra~~

${}^2\text{He } \uparrow\downarrow$   
 $1s$

Octet when  
 outer shell filled  
 w/  $8e^-$

## Election Dot Notation

$\overset{3}{\underset{0}{0}} \overset{7}{0}$

$\overset{6}{\underset{2}{0}} \overset{6}{\underset{0}{0}} \text{ Symbol } \overset{0}{\underset{0}{0}} \overset{5}{\underset{4}{0}}$

fill in one dot

for each electron  
 in highest number  
 energy level

What does it all mean?

17

1.  $n$  (orbital) says what level you are in

2.  $l$  describes your sublevel

$s, p, d, f, g$

$s = 2e^-$

combine  
w/ previous  
page

3

$\#e^-$  in each space orbital  
 $= 2 \times \text{space orbital } \#$

$p = 6e^-$

$d = 10e^-$

$f = 14e^-$

4 Learn the order it goes in.

Follow 3 Guides.

Aufbau Principle - ~~Follow~~ fill atoms w/  $e^-$  from  
lowest to highest energy level

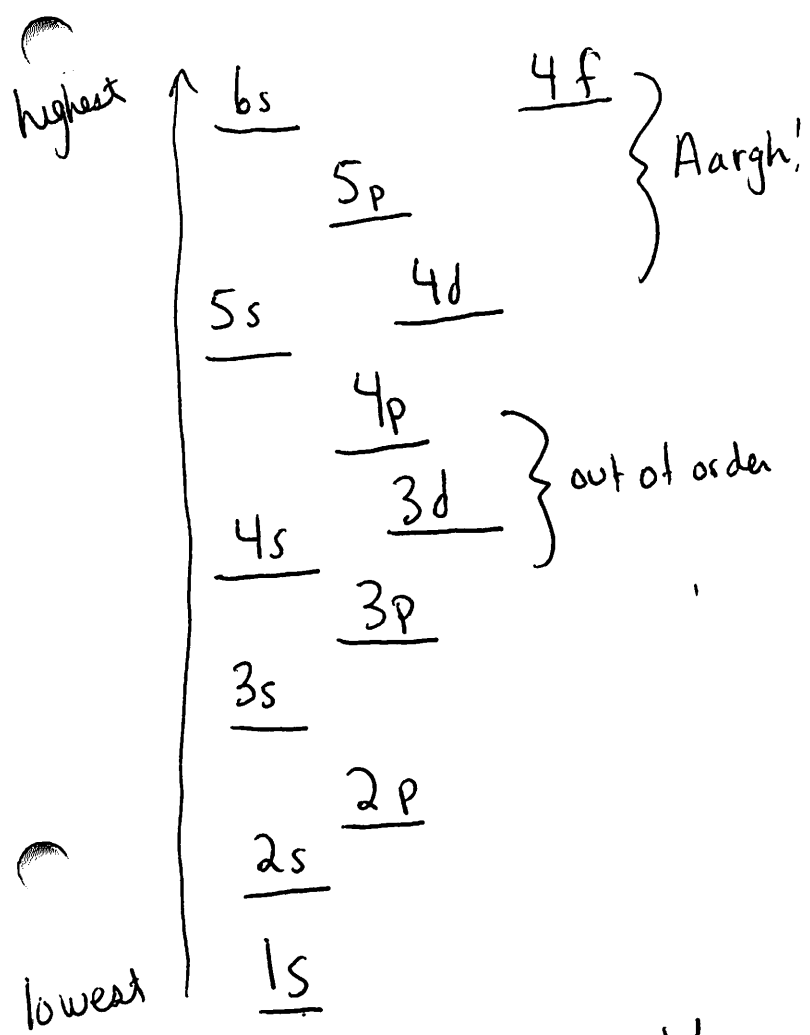
Hund's Rule  $\rightarrow 1e^-$  per space <sup>orbital</sup> level b/fore doubling

Pauli Exclusion Principle No 2  $e^-$  have the same 4

Quantum #'s

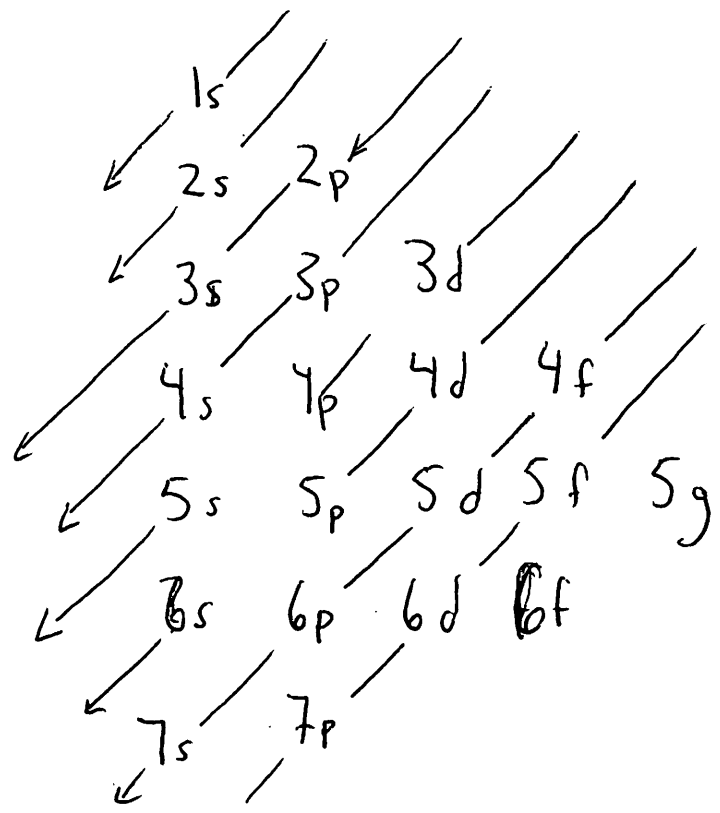


# Energies of E levels



Learn this order. It is how they get filled

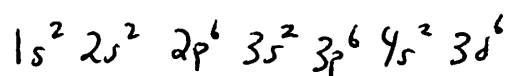
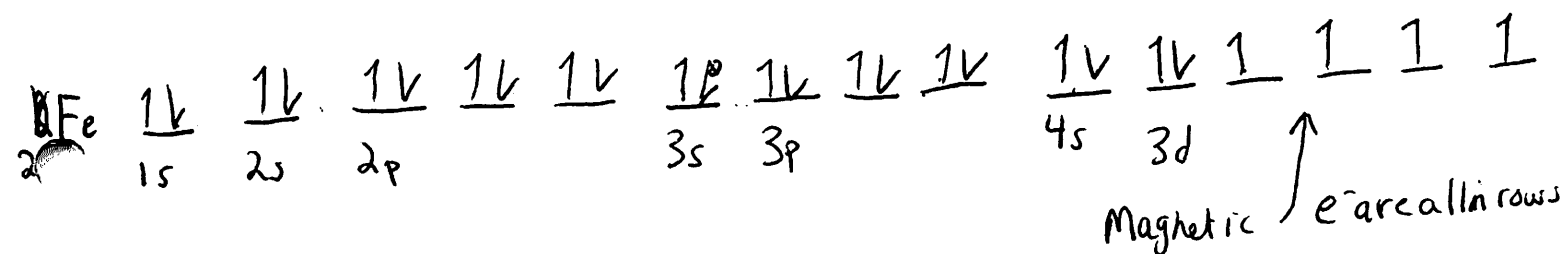
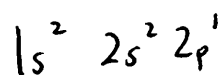
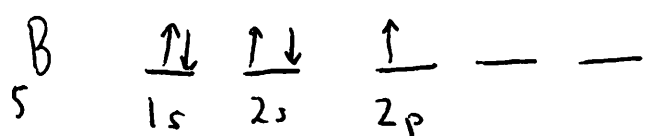
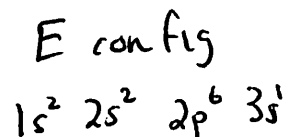
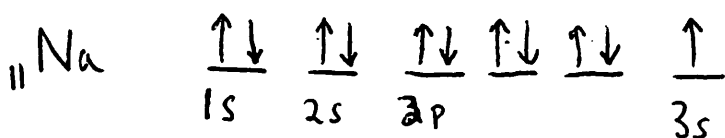
## Learn this filling scheme

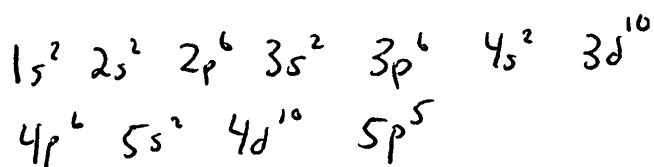
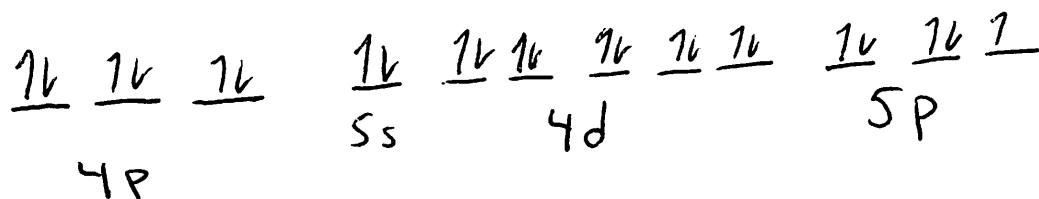
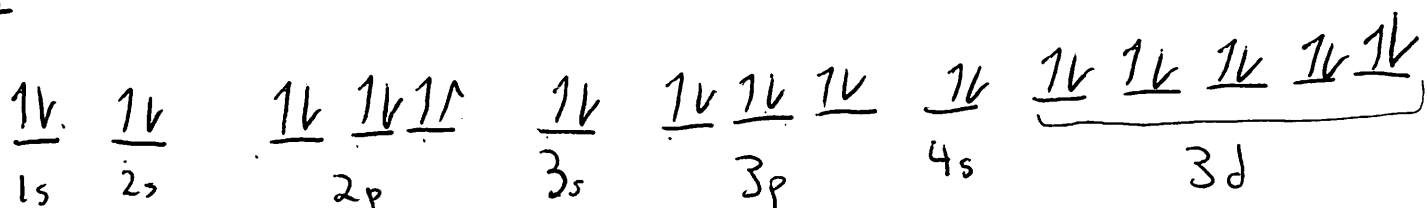


Very easy

# Ex Orbital Elec config Problems

Orbital

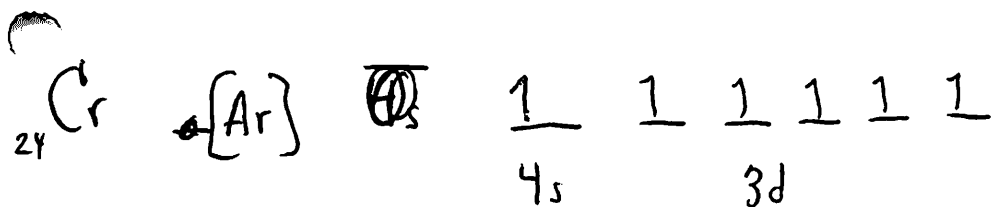
~~Electron~~

$${}_{53}\text{I}$$


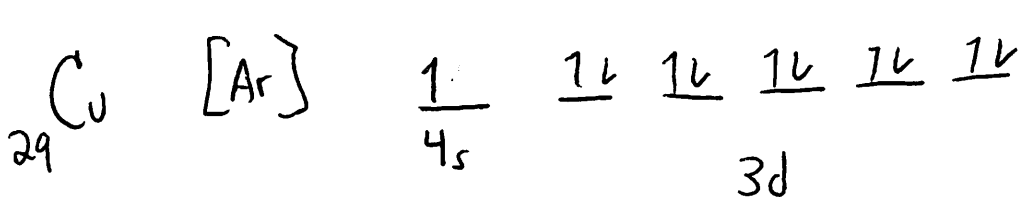
tell kids w/ short Hand Halogens

20

# Exceptions



more favorable for  $e^-$  to go in alignment here

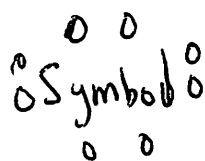


more favorable for  $e^-$  to fill 3d level

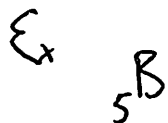
Draw how you would think they go then how actually go

$e^-$  dot

fill in 1 dot for highest number energy level



all want 8 in outermost level



Talk about Noble Gases

